

### REMARKS

Entry of this amendment under the provisions of 37 C.F.R. 1.116 is respectively requested. Claim 1 is now previously presented claim 18 rewritten in independent form, including the recitations in intermediate claim 15 and canceled claim 28. No new issues requiring any further search or consideration are raised.

This amendment is presented pursuant to a telephone conversation between the undersigned and Examiner Chen by telephone on September 29, 2006. The undersigned noted that the public PAIR system indicated that an Advisory Action had been handed in, but not yet mailed. The undersigned suggested that the limitation of claim 28, discussed on pages 9 and 10 of Applicants' paper filed on September 5, 2006, be included in claim 1. Examiner Chen suggested further clarifying amendments to claim 1. It was the understanding of the undersigned, based on that telephone conversation, that the amendment filed on September 5, 2006 would be entered. The form of the amendment to claim 1 made herein is based on the previous amendment being entered.

Examiner Chen is thanked for his time and the courtesy extended to the undersigned during the telephone interview.

This application, as amended herein, contains claims 1 - 3, 6 - 9, 11 - 14, 16, 17, 19 and 26-27. Claims 4, 5, 10 and 20 - 25 were previously canceled. Claims 15 and 18 were canceled in the amendment mailed on August 31, 2006. Claim 28 has been canceled in this paper.

Claims 1-3, 6-9, 11-19 and 26-28 were rejected as being obvious over Arkles et al. ('531). This rejection is respectfully traversed.

Claim 1, by its very terms, before the final office action, recited:

depositing a first layer on the substrate by plasma enhanced atomic layer deposition of a tantalum halide precursor in the presence of a plasma containing hydrogen and nitrogen

Claim 1 has been amended herein to explicitly recite that the deposition of the first layer and, by way of clarification, the second layer includes:

- a. exposing the substrate to the tantalum halide carried by an inert gas;
- b. exposing the substrate to the plasma; and
- c. repeating a. and b. approximately 40 - 800 times until a desired thickness of the first layer is obtained.

Thus, claim 1 now explicitly recites method steps associated with plasma enhanced atomic layer deposition.

Further, as noted in response to the previous office action, claim 1 also recites in a method for forming a bilayer of tantalum nitride and tantalum on a substrate, reducing concentration of nitrogen in the plasma to zero so that a substantially nitrogen free second layer of tantalum is formed.

Finally, claim 1 now recites that the second layer of tantalum comprises amorphous tantalum. It is respectfully submitted that Applicants' invention, as set forth in claim 1, is not taught or suggested by the art of record.

It is respectfully submitted that the rejection is simply inadequate for the following reasons. First Claim 1 now recites that the second layer of tantalum comprises amorphous tantalum. As previously noted, applicants' specification, at page 16, lines 15 - 28, notes, in pertinent part, that:

This is partly because the Ta PE-ALD layer has an amorphous structure which contributes to the copper diffusion barrier properties by reducing the number of grain boundaries (Grain boundaries are the predominant copper diffusion mechanism). Further, the inherently better copper diffusion barrier property of the TaN, as opposed to that of a Ta single layer, positively contributes to the resulting diffusion barrier properties. In summary, both the amorphous PE-ALD tantalum layer and PE-ALD tantalum nitride layer positively contribute to the resulting diffusion barrier properties.

The rejection of claim 1 is also deficient for the same general reasons as set forth for claim 1 above. First, the Office Action of May 31, 2006 fails to deal with recitations of claim 28, now included in claim 1. Second, Arkles et al. is simply deficient for formulating a

rejection of claim 1. While Arkles et al. does teach an amorphous tantalum nitride layer, it does not teach or suggest an amorphous nitrogen free tantalum layer. In view of the above, it is submitted that claim 1 is also directed to patentable subject matter.

It is also noted that the final rejection in no way addresses the recitations of claims 18, and intermediate claim 15, which are now included in independent claim 1. Arkles et al. is directed to CVD (chemical vapor deposition) and not to plasma enhanced atomic layer deposition, a completely different technology. This is why the rejection does not and can not address the recitations of cancelled claims 15 and 18, which are now included in claim 1. These matters are discussed in detail below.

A careful review of the details of the rejection on pages 2 and 3 of the final office action shows that there is not a single word directed to the recitations of claim 15 or claim 18. Nowhere does the rejection deal with the recitations of claim 1 of exposing a substrate to a tantalum halide carried by an inert gas and to a plasma, repetitively approximately 40 - 800 times, until a desired thickness of the first layer is obtained. Thus, the rejection simply does not deal with or reach claim 1, as amended herein, to include the recitations of claims 18, and those of intermediate dependent claim 15. As noted above, there is a reason for why the rejection is does not deal with or reach claim 1. It is related to the second point raised above, and addressed immediately below.

Arkles et al. is simply a deficient reference for the rejection of claim 1, as amended herein. The office action must be silent on exposing a substrate to a tantalum halide carried by an inert gas and to a plasma repetitively approximately 40 - 800 times until a desired thickness of the first layer is obtained, simply because there is no teaching or suggestion in Arkles et al. of such an approach. A careful reading of Arkles et al. discloses only conventional CVD (chemical vapor deposition). There is no teaching or suggestion in Arkles et al. of using plasma enhanced atomic layer deposition, and exposing a substrate to a tantalum halide carried by an inert gas and to a plasma repetitively approximately 40 - 800 times until a desired thickness of the first layer is obtained, as specifically recited in claim 1. CVD and atomic layer deposition are two completely different technologies, and Arkles et al. is directed entirely to CVD. There is not a word in Arkles et al. concerning using plasma enhanced atomic layer deposition, as specifically recited in claim 1. Thus, it is respectfully submitted that the rejection of claim 1 must now be withdrawn.

As noted in Applicants' prior paper, the method of claim 1 is especially useful in forming a diffusion barrier for copper, as noted in dependent claim 6. Advantageously, the bilayer is formed by establishing the conditions for deposition of a tantalum nitride layer, and then removing nitrogen from the plasma to obtain a nitrogen free tantalum layer.


In view of the above, it is submitted that claim 6, is also directed to patentable subject matter.

The remaining claims depend from claim 1. These claims include further recitation which in combination with those in claim 1, are not disclosed or suggested in the art of record. For the reasons set forth above with respect to claim 1, it is submitted that these claims are also directed to patentable subject matter.

In view of the allowable nature of the subject matter of all of the claims, if the Examiner cannot issue an immediate allowance, it is respectfully requested that the undersigned be contacted to resolve any remaining issues.

A check in the amount of \$120 for a one-month extension of time for the filing of this paper is enclosed.

Respectfully submitted,

  
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